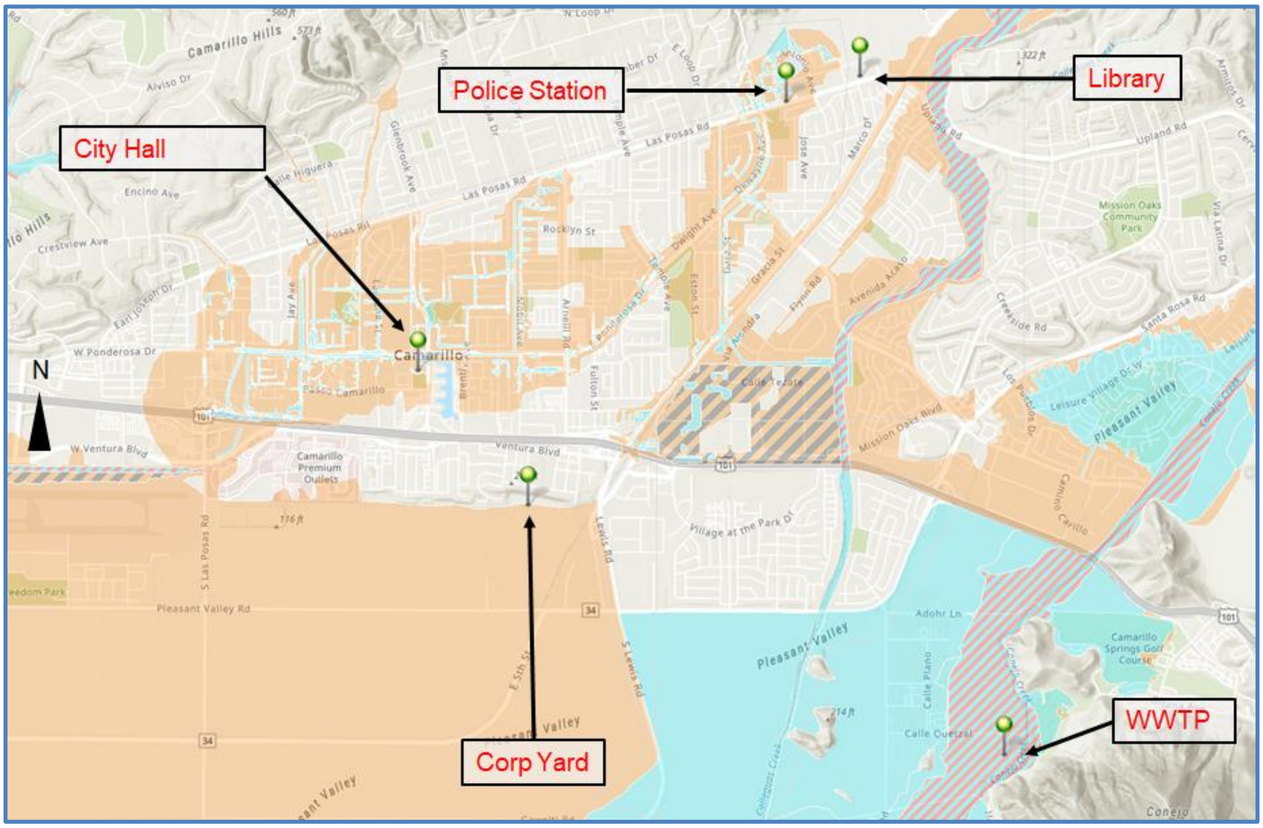
CITY OF CAMARILLO:

SOLAR+STORAGE MICROGRID FEASIBILITY STUDY SUMMARY



Presented by:

Clean Coalition and TRC Companies

20 October 2020

Clean Coalition
Making Clean Local Energy Accessible Now

TRC

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1 Executive Summary

The Clean Coalition was engaged by the City of Camarillo (City) under Request for Qualifications (RFQ) CH-5067 to study the feasibility of providing standby power for five City facilities during an electrical grid power outage or other natural disaster.

The five facilities consist of City Hall, Corp Yard, Library, Police Station, and the Wastewater Treatment Plant (WWTP). The study reviewed the feasibility of providing a standalone standby power system using a combination of solar and battery power at each of the five sites when compared to using only a diesel generator. The system was designed to provide standby power for a minimum of five days (120 hours) of continuous usage.

The study showed that the most feasible and economical solution was to incorporate a hybrid system that incorporates solar, storage and diesel generation at four of the five sites, providing the City with utility bill savings over the life of the project. Combining solar+storage+diesel generation into a hybrid microgrid will provide the City with a resilient system that can handle the more frequent shorter term (1-2 hour) outages on solar and battery alone with a diesel generator to be used only when needed for longer term emergency outages.

Specific project goals that were discussed at the March 18, 2020 kickoff meeting included:

- Standby power must be 150% of the average daily use and meet peak demand.
- The system must be capable of providing 120 hours of continuous power for emergency use, relying solely on on-site battery storage resources. Solar panels must be designed to charge the batteries to extend the minimum required duration of 120 hours.
- The project team will identify potential structural concerns at any of the sites.
- The project team will address site specific requirements (i.e. pumps at Corp Yard, additional emergency demand at Constitution Park), reviewing and incorporating any previous solar or alternative energy studies as applicable.
- The project team will provide high-level cost estimates and performance comparison of generator vs. battery for emergency backup including daily runtime costs and anticipated life cycle costs of 30 years.
- The project team will identify any grants or other potential funding opportunities.

This study investigated the feasibility of using four unique combinations of generation resources to meet the City of Camarillo's emergency power needs. The alternatives investigated are as follows:

- Solar+storage (or photovoltaic panels plus "battery")
- Storage (or "battery") only
- Diesel generator only (also referred to as "diesel" or "genset")
- Hybrid (a combination of solar+storage+diesel generator)

The City's original design to install the diesel generator only alternative for emergency backup power at City Hall and the Corp Yard was used as the base design criteria in order to compare the feasibility of the other three alternatives. The feasibility of solar+storage was studied to determine if the facility's emergency power needs could be met without using fossil-fuel-based infrastructure. Three of the systems described above would effectively operate as microgrids, utilizing a microgrid controller to manage the various systems within the microgrid during normal use and during an outage. The diesel generator only solution would not require a microgrid controller to manage resources, and instead only turn on in the event of an emergency outage. The storage only alternative would require it to be charged fully using the grid prior to an outage in order to sustain the five-day requirement without an alternative way for recharging during the outage. This study investigates and compares both the technical and economic feasibility of each of the alternatives.

Two high-level financing options were explored to study the feasibility for each alternative, assuming a 30-year project life term and a 3% discount rate. First, a City-owned owned model was developed along with an associated cash flow analysis for the project lifetime. Next, a PPA (or third-party) ownership model was assessed where a third-party would pay for the design, installation, maintenance and operating costs and the City would in turn pay the third-party for its energy use over the term of the agreement. The following key assumptions were used for each of the ownership models:

Table 1: Hybrid scenario financial calculation parameters

City Owned and PPA Model	PPA Model Only
30-Year Project Lifetime	$0 Upfront PPA Payment
O&M Start Year: Year 2 3% Discount Rate	PPA Starting Rate: • City Hall: $0.17 • Corp Yard: $0.25 • Library: $0.16 • Police Station: $0.17 • WWTP: $0.11
3% Annual Escalation Rate	$ PPA Escalation Rate
O&M Cost Per Year: $0.005/WDC	$1 End of Term Buyout

In a PPA financing model, a third party finances, owns and operates the equipment, and the City pays the third party for the energy it uses at an agreed PPA rate. The third-party can take advantage of the tax benefits (e.g. Investment Tax Credits (ITC)) available on renewable energy equipment since it is a private entity. The potential benefits are reflected in the PPA rates that the City would pay. The City would save money over the life of the agreement assuming utility rates increase and the City continues to pay the same locked-in PPA rate for many years. The information below summarizes the pros and cons between a City Ownership and PPA Ownership model.

Table 2: Financing model Pros/Cons

Financial Model	Pros	Cons
City Ownership	City benefits directly from cost savings from the production and sale of excess power generation	City will be responsible for the ownership and maintenance of the assets
	City will benefit directly from grants such as the Self-Generation Incentive Program (SGIP)	City does not qualify for business Investment Tax Credit (ITC) incentive
		High upfront capital cost

PPA Ownership	Third-party owned and maintained	City does not qualify for any tax benefits
	Minimal upfront capital cost to City	City continues to pay PPA rate to third party
	Predictable and lower cost energy rates for duration of contract	City does not benefit directly from sale of excess power generation back to the grid
	Relieves City from fixed operation and maintenance costs, system design complexities, permitting process, construction, and financial responsibilities	
	Can purchase system from third party typically after year 6	
	Third-party qualifies for business ITC incentive and may reflect savings in PPA rate	

From an operations and maintenance perspective, battery manufacturers are providing manufacturing warranties of 10-15 years, and battery replacements after the warranty period are anticipated to be much less expensive as battery costs continue to trend downward.

Table 3 below shows the expected economic results of each site:

Table 3: Summary of economics for each scenario

Scenario		CapEx & OpEx					Utility Bill Savings		Economics		
Site	Generation	Total CapEx [$]	Total Annual OpEx [$]	30-Year OpEx	Total 30-Year Costs [$]	Diesel Generator Cost [$]	Annual Bill Savings [$]	30-year Bill Savings	City Owned Net-Present-Value (NPV) [$]	PPA Net-Present-Value (NPV) [$]	Return on Investment (ROI) [%]
City Hall	PV+BESS	$ 6,179,625	$ 3,200	$ 1,556,000	$ 7,735,625	$ -	$ 96,000	$ 2,880,000	$ (4,580,000)	$ (214,000)	-72%
	BESS only	$ 14,231,875	$ 1,000	$ 5,330,000	$ 19,561,875	$ -	$ 25,100	$ 753,000	$ (1,706,000)	$ -	-132%
	Diesel only	$ 253,183	$ 4,985	$ 149,544	$ 402,726	$ 230,166	$ -	$ -	$ (538,355)	$ -	-
	Hybrid	$ 1,409,416	$ 4,417	$ 367,918	$ 1,777,334	$ -	$ 42,100	$ 1,263,000	$ (651,392)	$ 226,837	-4%
Corp Yard	PV+BESS	$ 1,157,010	$ 550	$ 301,500	$ 1,458,510	$ -	$ 13,900	$ 417,000	$ (987,000)	$ (60,700)	-96%
	BESS only	$ 2,029,250	$ 1,000	$ 760,000	$ 2,789,250	$ -	$ 2,700	$ 81,000	$ (237,000)	-	-133%
	Diesel only	$ 40,675	$ 2,351	$ 70,529	$ 111,204	$ 36,977	$ -	$ -	$ (316,107)	-	-
	Hybrid	$ 189,948	$ 2,351	$ 70,529	$ 96,629	$ -	$ 4,800	$ 144,000	$ (170,130)	$ (73,626)	-50%
Library	PV+BESS	$ 13,414,750	$ 8,750	$ 2,962,500	$ 16,377,250	$ -	$ 281,200	$ 8,436,000	$ (8,310,000)	$ 29,400	-48%
	BESS only	$ 28,439,875	$ 4,000	$ 10,620,000	$ 39,059,875	$ -	$ 71,500	$ 2,145,000	$ (33,529,000)	-	-130%
	Diesel only	$ 769,016	$ 7,424	$ 222,716	$ 991,733	$ 699,106	$ -	$ -	$ (996,375)	-	-
	Hybrid	$ 2,884,815	$ 9,054	$ 442,040	$ 3,326,855	$ -	$ 109,900	$ 3,297,000	$ (1,611,989)	$ 454,099	1%
Police Station	PV+BESS	$ 3,683,625	$ 2,100	$ 864,000	$ 4,547,625	$ -	$ 68,500	$ 2,055,000	$ (2,480,000)	$ 17,100	-59%
	BESS only	$ 10,607,875	$ 800	$ 3,924,000	$ 14,531,875	$ -	$ 10,400	$ 312,000	$ (1,281,100)	-	-134%
	Diesel only	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ (550,493)	-	-
	Hybrid	$ 867,680	$ 986	$ 113,177	$ 980,857	$ -	$ 36,200	$ 1,086,000	$ (162,804)	$ 145,240	35%
WWTP	PV+BESS	$ 53,492,375	$ 35,300	$ 12,259,000	$ 65,751,375	$ -	$ 305,400	$ 9,162,000	$ (39,700,000)	$ (6,200,000)	-59%
	BESS only	$ 158,727,500	$ 20,000	$ 62,000,000	$ 220,727,500	$ -	$ 60,800	$ 1,824,000	$ (193,537,000)	-	-136%
	Diesel only	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ (3,474,215)	$ -	0%
	Hybrid	$ 10,911,040	$ 12,966	$ 1,187,830	$ 12,098,870	$ -	$ 336,200	$ 10,086,000	$ (5,879,853)	$ 1,088,192	-8%

As shown in the analysis, the first three resource scenarios for City-owned financing were not economically feasible for each of the sites. A hybrid solution approach (solar+storage+diesel) was the most economically feasible when using a PPA financing model.

It is anticipated that shorter term (1-2 hour) outages can be powered from battery storage alone without needing to turn on the diesel generators. For longer duration outages, the diesel generator may be needed as a backup resource. In addition, the Table 4 below shows the percent of average daily load that can be supported indefinitely using just the solar+storage resources if the diesel generators were to run out of fuel during an outage. This hybrid combination provides the City with an added level of resiliency over diesel generation alone.

Table 4: Percentage of average daily load that solar+storage can support indefinitely

Percentage of Average Daily Load Supported Indefinitely				
City Hall	Corp Yard	Library	Police Station	WWTP
19.6%	16.0%	21.8%	25.4%	18.4%

Table 5 below summarizes the asset sizes and costs as well as the utility bill savings for the recommended hybrid scenario.

Table 5: Hybrid Scenario Asset Capacities and Financial Metrics

	Camarillo Facilities				
System Configuration	City Hall	Corp Yard	Library	Police Station	WWTP
PV DC Capacity (kW)	224.4	27.2	809	197.2	2,593
BESS Energy Capacity (kWh)	420	54.5	446	232	5,232
Utility Bill Savings ($)	42.1K	4.8K	109.9K	36.2K	336.2K
Total Cost ($)	1.60M	219.4K	3.53M	867.6K	10.91M
City Owned Ownership Model					
Payback Period (Years)	27.8	> 30	25.9	24.6	> 30
Net Present Value ($)	-651.4K	-170K	-1.61M	-162.8K	-5.87M
Project Term ROI (%)	-4%	-50%	1%	35%	-8%
Estimated SGIP Incentive ($)	77.9K	12.4K	156.1K	60.9K	868K
Power Purchase Agreement Ownership Model					
Net Present Value ($)	226.8K	-73.6K	454.1K	145.2K	1.09M
Estimated ITC Incentive ($)	194.0K	17.6K	683.6K	166.6K	1.87M

In addition to the economic benefits, the recommended hybrid solution provides enough solar resource to produce the same net energy as the building consumes, hence achieving zero net energy (ZNE) and is combined with a battery energy storage system (storage) that yields utility bill savings through avoided demand and energy charges at all five sites. For each site building loads can likely be met by the solar+storage during the day and for a 1-2 hour power outage event at full load. Depending on the state of charge of the battery energy system, the building load during an outage, and the solar production, these loads could be extended by another 1-2 hours on storage alone. Once the battery storage has been fully depleted, the diesel generators would turn on to meet the remaining load during the evening and throughout the night if needed during an emergency. This cycle of recharging during the day and depletion of the battery during the evening would then repeat to carry the facilities through a five-day power outage. The Corp Yard has existing solar, but no battery storage. During the day only a portion of the necessary building loads at the Corp Yard can be powered by the existing solar panels, so the generator would need to be turned on in the event of an outage.

The recommended hybrid solution delivers a net decrease in carbon emissions for normal operations, assuming a portion of the energy delivered from the grid is generated from fossil-based-fuels. This net reduction comes from the use of solar energy to displace energy from the grid as well as from reduced runtime for the diesel during an extended outage (since solar+storage is used first to serve load, only using the diesel as needed when solar+storage is not generating enough power to cover building loads). Table 6 below provides a summary of these emissions benefits for the recommended hybrid solution. The annual models run for this table included one five-day outage and required monthly maintenance runs of the diesel generators. Since the hybrid alternative was sized for the most economic benefit, the carbon reduction approaches 100%, but does not quite reach that goal due to the need to run the diesel generators during the anticipated outages.

Table 6: Hybrid solution carbon emissions reductions.

	Carbon Emissions Metric	City Hall	Corp Yard	Library	Police Station	WWTP	Total
Hybrid 150%	Carbon Footprint Reduction [lbs/yr]	167.7K	15.35K	539.2K	140.7K	1.76M	2.62M
	Carbon Reduction in Annual Home Equivalents	52	5	166	43	540	805
	% Reduction	82%	60%	80%	84%	91%	87%

1.1 Findings and Recommendations

The hybrid design provides the following benefits:

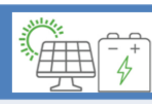
- Sites can be funded by a cost-effective PPA
- Meets the City's desired five-day power outage resilience target
- Short term (1-2 hour) outages sustained using the battery without having to turn on the generator
- Provides a significant carbon footprint reduction
- Results in zero net energy under normal operation
- Provides utility bill savings

The following recommendations for a hybrid design satisfy City of Camarillo's project goals and are provided to help guide the City's decision-making process:

- Install solar+storage at the sites with the best economic potential: City Hall, Library, Police Station, and WWTP to reduce the utility bill charges and cover short term outages.
  - Installing solar+storage will, on average, reduce utility bill charges by 68% for the Library and City Hall and by 79% for the Police Station and WWTP facilities.
- Keep in place the existing solar array at the Corp Yard.
- Install new diesel generators at City Hall and the Corp Yard and keep in place the existing diesel generators at the Police Station and WWTP to provide backup power when needed during long-term outages.

Table 7 below shows the final recommended resource scenarios for each site as determined by the economic analyses. It assumes that PPA financing is the preferred method.

Table 7: Recommended sites and resources for investment

			
City Hall	✓	✗	✓
Corp Yard	✓	✗	▬
Library	✗	✗	✓
Police Station	▬	✗	✓
WWTP	▬	✗	✓

Legend
- ✓ Feasible
- ✗ Not Feasible
- ▬ Existing

1.2 Conclusion

Based on the research and analysis performed for this Feasibility Study, the Clean Coalition and TRC team have reviewed and analyzed the technical, economic, and environmental constraints needed to develop and prepare recommendations. The study showed that the most feasible and economical solution was to incorporate a hybrid system that incorporates solar, storage and diesel generation, providing the City with utility bill savings over the life of the project. Combining solar+storage+diesel generation into a hybrid microgrid will provide the City with a resilient system that can handle the more frequent shorter term (1-2 hour) outages on solar and battery alone with a diesel generator to be used only when needed for longer term emergency outages.

By engaging in this feasibility study, the City of Camarillo has demonstrated significant leadership in progressing its City and regional-based sustainability ambitions. Implementation of the cost-effective Hybrid solution will reduce the cumulative carbon footprint of the five sites by about 88%. In moving this project to the next phase of development, the City will further enhance their energy portfolio, sustainability, and resiliency goals.

Section 2 below provides a more detailed review of the system design parameters and performance aspects. It also provides an aerial view of the solar+storage as well as the solar+storage+diesel resource scenarios for comparison.

2 System Design and Performance Characteristics—Detailed by Site

2.1 Building Loads, Characteristics, and Bill Analysis

Table 8 provides a summary of the existing building energy and demand characteristics along with the Time-of-Use (TOU) rate tariff schedule and annual bill charges. Annual consumption reflects an assumed 10% reduction in energy due to energy efficiency measures the City may adopt.

Table 8: Summary of current (pre-solar+storage) Annual Building Loads, Operating Rate Tariffs and Associated Annual Utility Bill Charges, sorted highest to lowest

Site	SCE Time-of-Use Rate Tariff	Annual Consumption [kWh]	Peak Annual Demand [kW]	Annual Demand Charges [$]	Annual Energy Charges [$]	Annual Total Charges [$]	Blended Rate [$/kWh]
WWTP	TOU-8	3,907,545	1,190	$ 203,389	$ 215,569	$ 522,398	$ 0.1337
Library	GS-3-TOU-D	1,217,078	334	$ 92,288	$ 77,889	$ 204,456	$ 0.1680
City Hall	GS-3-TOU-D	378,700	118	$ 31,152	$ 26,126	$ 68,345	$ 0.1805
Police Station	GS-3-TOU-D	308,810	92	$ 21,425	$ 21,607	$ 52,352	$ 0.1695
Corp Yard	GS-3-TOU-R	42,687	18	$ 4,078	$ 3,078	$ 9,822	$ 0.2301

2.2 System Sizing

The systems were sized based on the utility usage data provided by Southern California Edison (SCE) that show 15-minute interval power (kW) data for each of the five sites. The relatively low annual consumption at the Corp Yard reflected in Table 6 above is due the existing solar panels offsetting a portion of the consumption throughout the year.

From this data, an average daily use energy profile was generated at each site and used to size the solar system capacity to meet 150% of the average daily load. The system was then verified to ensure that any peak power consumption could be handled as well as the potential for additional loads during an emergency within the 150% design criteria. The system was then sized to provide emergency power for a five-day outage duration. A 10% annual load reduction was applied to account for potential energy savings attributed to energy efficiency measures.

2.3 Site Layouts

The conceptual site layouts are shown in Figures 1 through 5 below for both the solar+storage and the recommended hybrid alternative for comparison. The system performance metrics for each facility indicate expected annual solar system generation profile based off system capacity, along with the annual storage utilization rate.

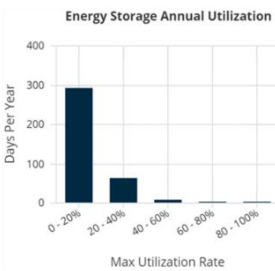
Figure 1: City Hall Site Layouts

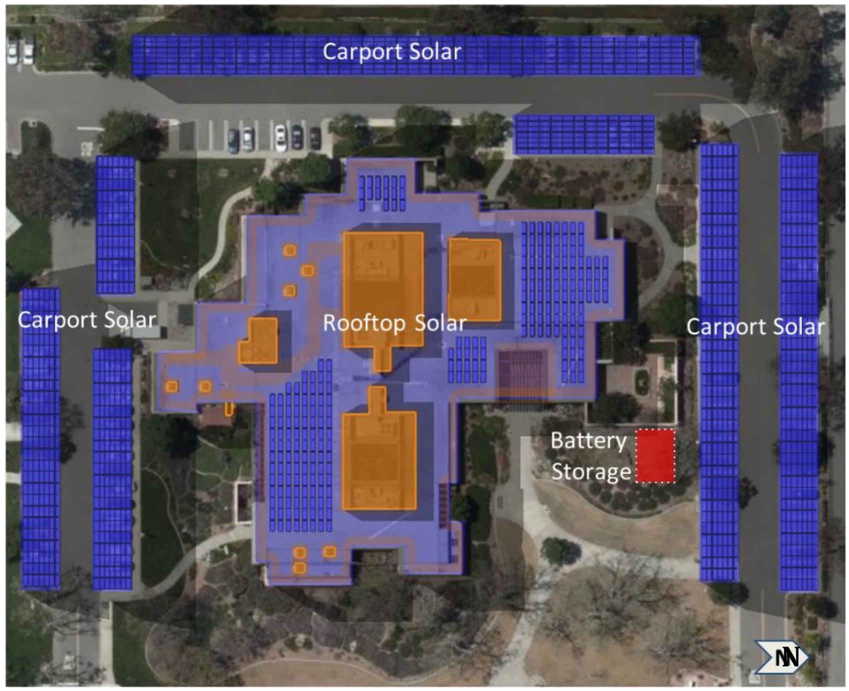
City Hall - Solar+Storage

Solar: 646 kW
Storage: 3 MWh

CapEx: $6.18M
NPV: -$214k

CO_2 Reduction:
256%
161 homes



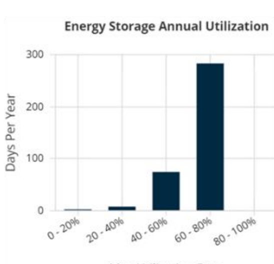


City Hall – Hybrid

Solar: 224.4 kW
Storage: 420 kWh
Proposed Diesel Gen:
139 kW

CapEx: $1.41M
NPV: $226.8k

CO_2 reduction: 82%
52 homes



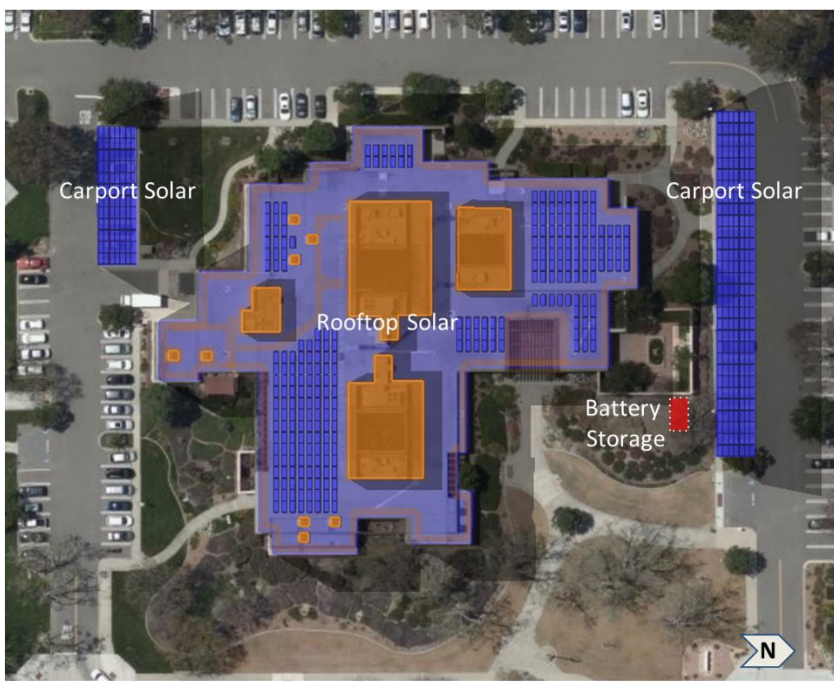
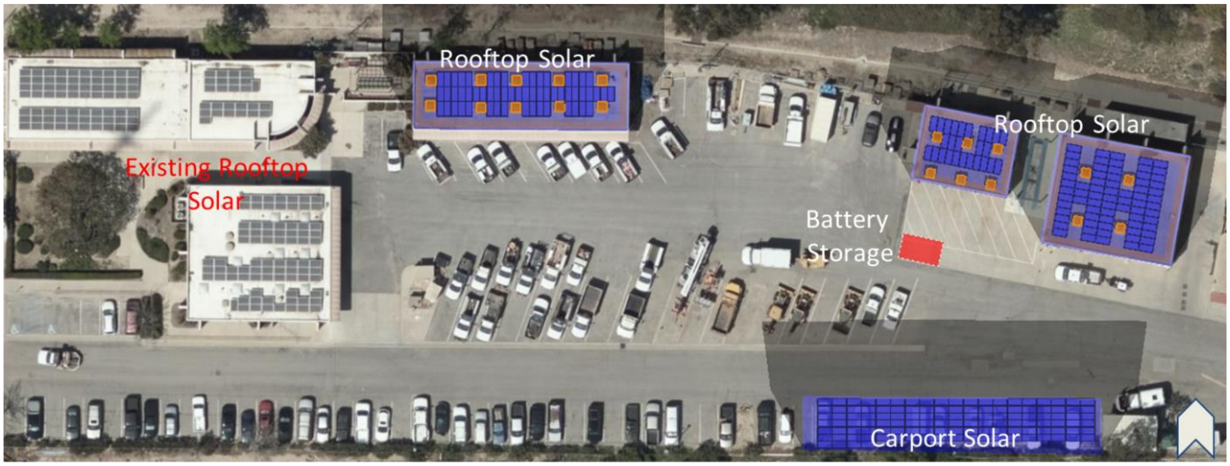


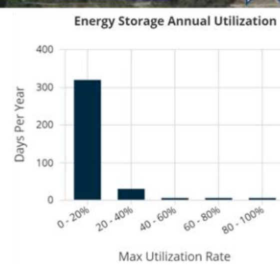
Figure 2: Corp Yard Site Layouts

Corp Yard - Solar+Storage



Solar: 108 kW
Storage: 575 kWh
CapEx: $1.16M
NPV: -$60k

CO_2 reduction: 309%
24 homes



Corp Yard - Hybrid

Solar: 27.2 kW
Storage: 54.5 kWh
CapEx: $189.9k
NPV: -$73.6k

Proposed Diesel Gen: 21 kW

CO_2 reduction: 60%
5 homes

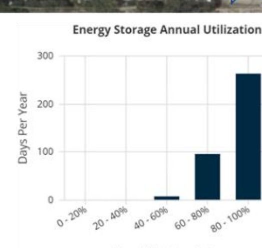


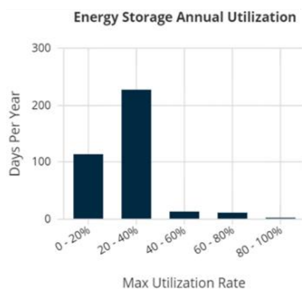
Figure 3: Library Site Layouts

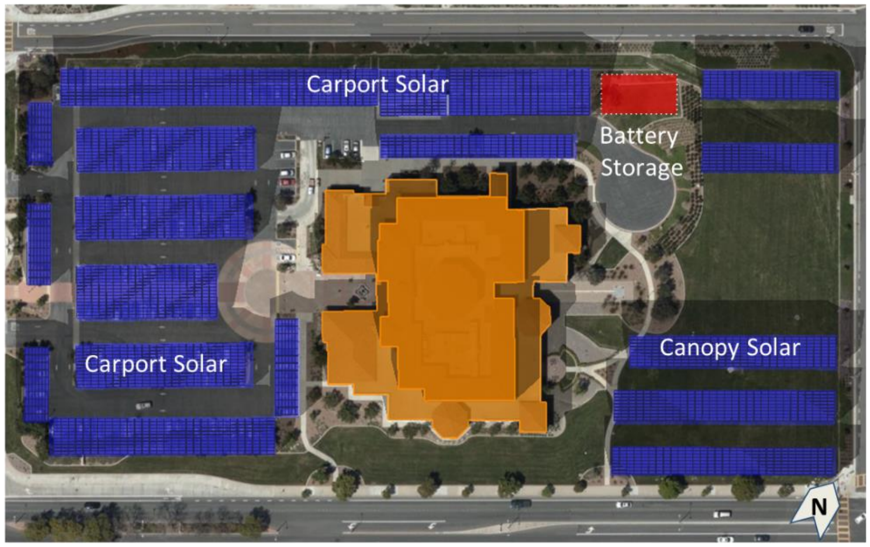
Library - Solar+Storage

Solar: 1.75 MW
Storage: 5 MWh

CapEx: $13.4M
NPV: $29.4k

CO_2 reduction:
197%
407 homes



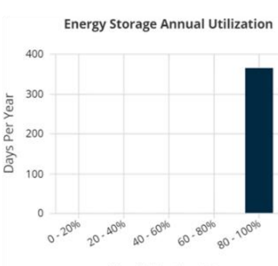


Library - Hybrid

Solar: 809 kW
Storage: 446 kWh
Proposed Diesel Gen:
500 kW

CapEx: $2.88M
NPV: $454.1k

CO_2 reduction: 80%
166 homes



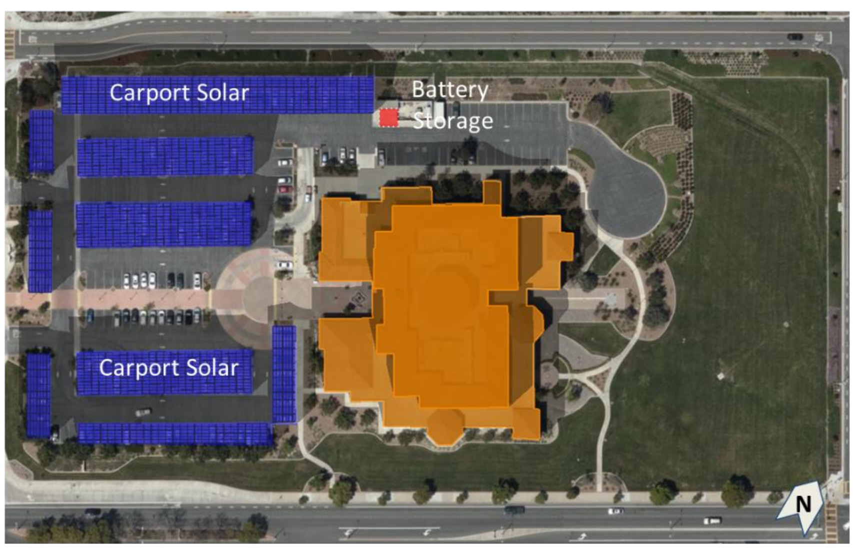
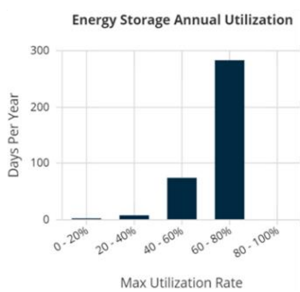


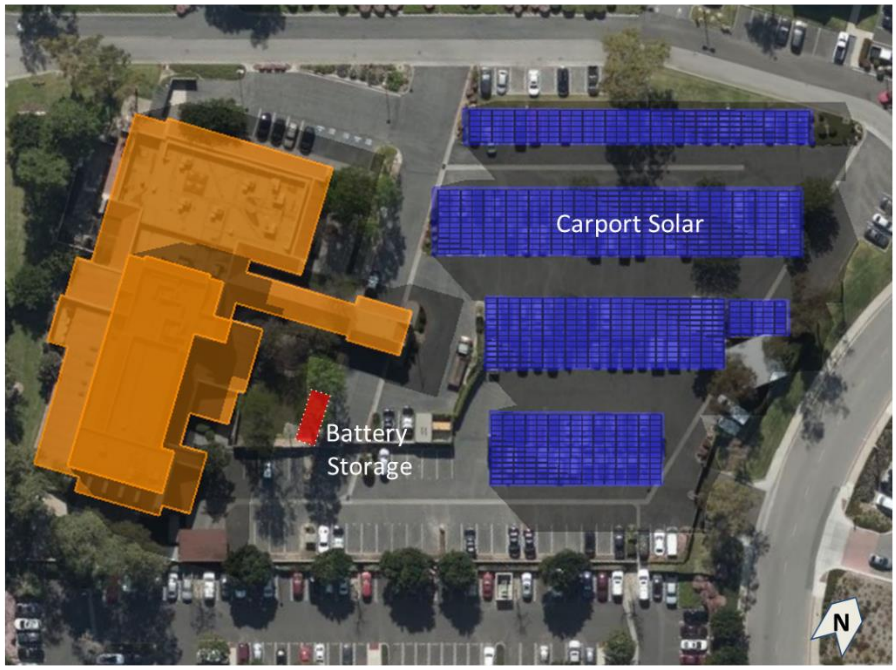
Figure 4: Police Station Layouts

Police Station - Solar+Storage

Solar: 422 kW
Storage: 1.55 MWh
Existing Diesel Gen: 175 kW

CapEx: $3.68M
NPV: $17.1k
CO_2 reduction: 196%
101 homes



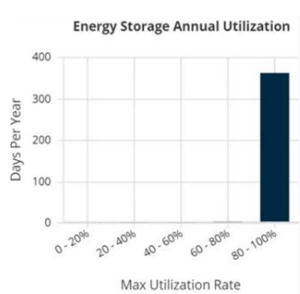


Police Station - Hybrid

Solar: 197 kW
Storage: 232 kWh
Existing Diesel Gen: 175 kW

CapEx: $867.7k
NPV: $145.2k

CO_2 reduction: 84%
43 homes



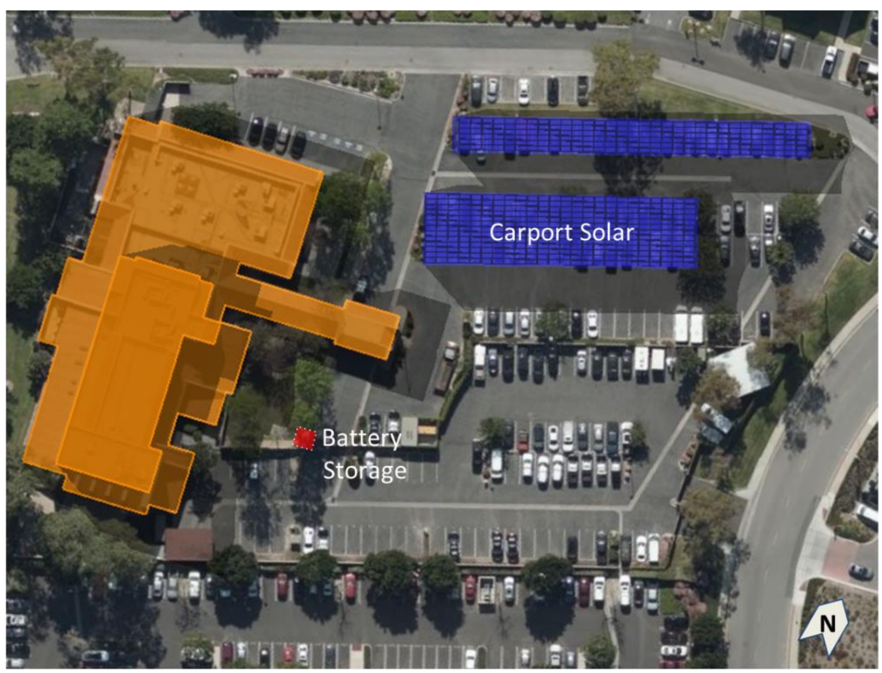


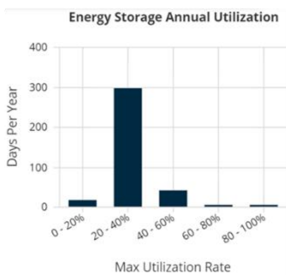
Figure 5: WWTP Site Layouts

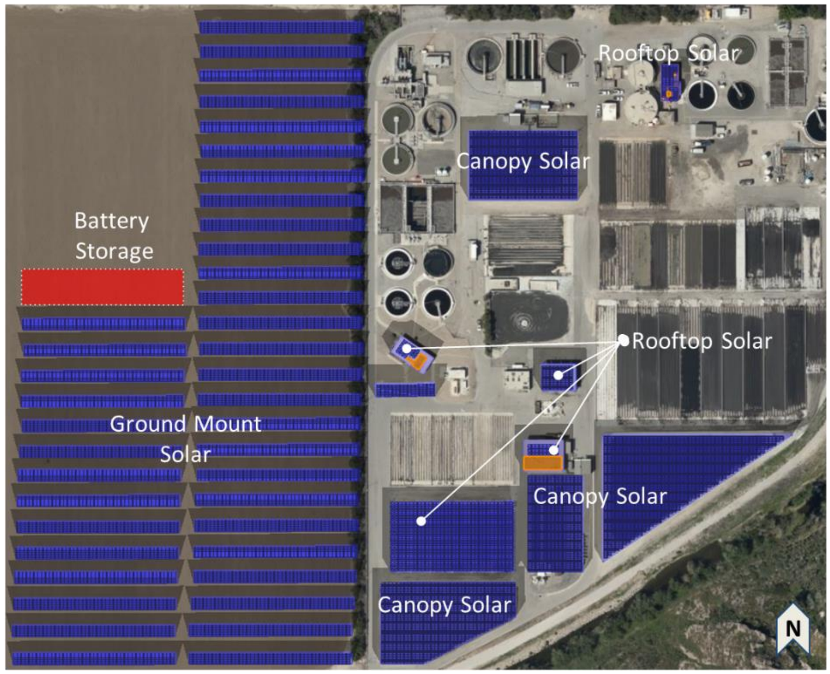
WWTP - Solar+Storage

Solar: 7.06 MW
Storage: 20.5 MWh
Existing Diesel Gen:
500 kW
1270 kW

CapEx: $53.5M
NPV: -$6.2M

CO_2 reduction: 275%
1639 homes





WWTP - Hybrid

Solar: 2.6 MW
Storage: 5.2 MWh
Existing Diesel Gen:
500 kW
1270 kW

CapEx: $10.91M
NPV: $1.09M

CO_2 reduction: 91%
540 homes